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GENERAL ELECTRIC

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TITLE

PRODUCTION TEST IP-468-A-FP, PROGRAM FOR
EVALUATION OF ALPHA EXTRUDED FUEL CORES

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PRODUCTION TEST IP-468-A-FP, PROGRAM FOR
EVALUATION OF ALPHA EXTRUDED FUEL CORES

January 31, 1962

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INTRODUCTION

Currently, all normal production HAPU fuel cores are rolled into rods at Fernald, consequently, HAPU is dependent upon one vendor for a critical raw material. This arrangement does not appear to be consistent with good business practice, and it is desirable to have an alternate fuel source tested and available. Mallinckrodt's Weldon Spring plant contains an extrusion press for the gamma bar extrusion and a logical sequence of operations should permit further extrusion in the alpha phase to the desired rod size. As alpha extrusion is also purported to be a slightly cheaper fabrication process than rolling, it appears appropriate to carry out a testing program to evaluate the alpha extruded fuel core as an alternate to the rolled fuel core.

OBJECTIVE

The specific objectives of this test are to evaluate: 1) the gross dimensional stability and 2) the gross irradiation performance of alpha extruded dingot uranium fuel cores. The ultimate objective of this test program being to establish an independent alternate uranium fuel core feed source.

TEST SUMMARY

In order to accomplish the objectives of this test program, irradiation testing will be carried out in three phases with Phase I and part of Phase II being authorized by this test.

Phase I

Ten measured monitor charges containing alpha extruded dingot uranium fuel cores will be irradiated in an old reactor: four to 400 MWD/T, four to 800 MWD/T, and two to 1000 MWD/T. The fuel geometry will be OIIIN non-bumpered.

Phase II

Concurrently with the 10 Phase I monitor columns, about 800 OIIIN elements containing alpha extruded dingot fuel cores will be lot charged for irradiation to normal variable goal. Following favorable post-irradiation examination results from the four Phase I monitor columns discharged at 400 MWD/T, up to 25 tons per month of OIIIN alpha extruded dingot cores will be irradiated to normal variable goal for seven months. If no unusual experience occurs, the maximum quantity may be increased to 90 tons/month under separate authorization. Performance of the lot charged material will be monitored under authorization of the Quality Certification Program.

Phase III (Not authorized by this test)

As soon as details are completed and material is fabricated at the feed sites, HAPU will receive uranium fuel cores for a test which will be statistically designed to evaluate extrusion versus rolling and it may contain ingot and dingot uranium cores produced by either or both fabrication techniques. This evaluation will require up to 32 monitor tubes and will be carried out independently from Phases I and II. Details on this phase of the program will be covered in a supplement to this test.

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BASIS AND JUSTIFICATION

The incentives for testing extruded fuel cores have been thoroughly discussed in references 1 through 6. The justifications are summarized as follows:

a) Establish an Alternate Fabrication Route and Feed-Site

At present, all normal production uranium fuel cores, both ingot and dingot, are alpha phase rolled into rods and cut into core blanks at Fernald (NLO). It would appear there is some value in developing and having a second source of uranium fuel cores tested and available in the event of some incident at the Fernald rolling mill. Alpha phase extrusion of dingot metal into rods at the Mallinckrodt Chemical Works (MCW) Weldon Springs plant would eliminate the rolling of dingot bars at Fernald and would make the Weldon Spring plant a truly independent alternate feed site. This should reduce the effects of work stoppages resulting from mechanical failures, labor difficulties, etc., at either the NLO or MCW plants. Also, establishment of an alternate feed source could result in a competitive situation which may stimulate further metal quality improvements and over-all dollar savings in the feed site - reactor site complex.

b) Reduce Feed Site - Reactor Site Fuel Costs

The alpha phase extrusion program was originated and developed under the direction of the Working Committee of the Fuel Element Development Committee to produce fuel cores more economically than by rolling. Recent economic studies⁽⁷⁾ indicate the cost incentive is small and not nearly as great as originally estimated. For example, if dingot metal were alpha extruded by MCW instead of alpha rolled by NLO, the HAPO costs could be reduced about \$.02 per pound. This would be a savings of \$60,000 to \$80,000 per year at current dingot usage rates.

- (1) Letter, AT Gifford to LL German, "Extruded Fuel Cores, 8/13/59 (CONF-UNDOC).
- (2) HW-61733, "Anticipated Reductions In Uranium Deliveries", AB Greninger, 8/31/59 (SECRET)
- (3) HW-60962-A, "Design of Production Test IP-269-A-FP, Evaluation of the Stability of Cores from Extruded Tubes", HG Hodgson and RE Hall, 9/24/59 (SECRET)
- (4) Letter, RL Dickeman to AT Gifford, "Program For Evaluation of Alpha Extruded Fuel Cores, 8/15/61 (UNCLASSIFIED)
- (5) Letter, EA Weakley to MA Clinton, "Justification for Alpha Rod Extruded Dingot", 12/1/61 (UNCLASSIFIED)
- (6) Letter, JH Brown to JT Stringer, "Testing and Acceptance of (1) Alpha Extruded Dingot and (2) Oil Quenched Uranium Cores", 12/6/61 (UNCLASSIFIED)
- (7) HW-71447, "Mallinckrodt Alpha Extrusion of HGE-I&E Fuel Cores", DR Stenquist, 11/28/61.

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c) Uranium Fuel Core Quality

A third, not too tangible, justification may be that of improved uranium metal quality. Whether or not an extruded fuel core will prove to be of higher quality than a rolled fuel core, from the reactor irradiation performance viewpoint, is not known. There is little irradiation experience available for alpha extruded core material.⁽⁸⁾ The available information indicates only small differences in performance would be expected and the production risk appears correspondently small. It must also be stated that the quantities of test material authorized by this test will permit determination of only the gross differences between rolled and extruded fuel cores, should some exist.

TEST DETAILS

1. Reactor

This test could be performed equally well in any of the five (5) older reactors; however, in order to balance production test time between the reactors, B Reactor was chosen to conduct the following phases of the alpha extrusion test program:

Phase I: Charge, discharge, and special pickup of ten measured monitor charges.

Phase II: Lot-charge 25 tubes of unmeasured material concurrently with the 10 monitor tubes and up to twenty-five tons/month for a seven month period beginning about three months after the charging of Phase I.

2. Material

A. Fuel Elements

1. Geometry - The OIIIN fuel geometry will be utilized in all phases of this test.
2. Fabrication - Specific details concerning the fabrication and ex-reactor testing may be found in the test design document⁽⁹⁾. Alpha rod extruded dingot uranium core blanks will be utilized as opposed to normal production alpha rolled ingot or dingot⁽¹⁰⁾ core blanks. The cores will be fabricated by the "F" process⁽¹¹⁾ and will be clad in ALCOA X-8001 aluminum alloy jackets. All elements will conform

(8) HW-48918-D, "Final Report on Evaluation of Alpha Extruded Solid Uranium Fuel Elements, Production Test IP-58-A-87-FP", WH Hodgson and RE Olson, 10/15/58 (SECRET)

(9) HW-72541-A, "Design of Production Test-IP-468-A-FP, Program for Evaluation of Alpha Extruded Fuel Cores", WH Hodgson and MA Clinton,

(10) HW-69621, "Dingot Uranium Current Status and Recommendations for Additional Testing of Dingot Uranium", RD Shimer, 5/16/61.

(11) HW-47029, "Process Specifications, Fuel Element Manufacturing Processes", FPD.

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to the normal process specifications in effect at the time the material is prepared. Fuel elements for Phase I and the initial stages of Phase II will be non-bumpered. Material for the later stages of Phase II may be bumpered or non-bumpered depending upon initial test results and reactor fuel usage.

3. Water Mixer - Water mixer elements will be provided; however, use of the water mixer element will be at the discretion of the Manager, B Processing and the location will be recommended by Process Technology.

4. Monitor Charges

Phase I - Ten monitor columns will be supplied.

Phase II - Quality certification monitor charges will be supplied for each lot of lot charged material. They will be handled in accordance to the provisions specified in IP-216-A. (12)

5. Pre-Irradiation Measurements and Marking - Pieces in the Phase I monitor charges will have the following data recorded:

- a) Dingot number and chemistry.
- b) Complete UT-2⁽¹³⁾, SORT⁽¹⁴⁾, and visual core examination.
- c) A random sample of 50 to 60 pieces will receive bare core measurements of length, OD, ID, and warp - ellipticity.
- d) The canned fuel elements will receive:
 - 1. Total bond count (both external and internal).
 - 2. Weight measurements on odd pieces 1 through 23
 - 3. Length measurements on all pieces
 - 4. OD (1,2,3, and 4) measurements on all pieces
 - 5. ID (5 and 7) measurements on odd pieces 1 through 17

Pieces charged as monitor columns under Phase II will receive the same measurements and treatments as normal production quality certification charges.

6. Column Make-Up - FPD will make up the monitor charges and will place them in specially identified shipping pallets in charging order.

(12) HW-59271, "Supplement A to PT-IP-216-A, Evaluation of Performance of Normal Production I&E Fuel Elements, MA Clinton, 8/2/60 (SECRET)

(13) HW-8448-C, "PT-IP-310-A-FP, Determination of the Dimensional Stability of Uranium Fuel Cores Classified by the Fuel Core Test, MA Clinton, 4/27/61 (SECRET)

(14) HW-58447-C, "PT-IP-219-A-FP, Preliminary Evaluation of SORT for Segregation of Fuel Cores, RE Hall, 10/8/59 (SECRET)

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B. Dummies and Seating

The downstream dummy pattern and seating method in use at the time this test is charged shall be used.

C. Thermocouple Probes - Not required for this test.

D. Probolog - Not required for this test.

3. Irradiation

A. Charging

All monitor columns will be serially numbered and will be charged in numerical order with piece number one downstream. Each column shall have the fuel identification number (series and/or lot number) recorded opposite the tube number on the front face sequence sheet. Charging of the Phase I material will be followed by a representative of Research and Engineering. Monitor columns charged under Phase II will receive the same handling treatment as columns charged under authorization of PT-IP-216 - Quality Certification Production Test.

Monitor columns for Phase I will be charged into locations which will provide similar irradiation conditions for all tubes. Locations will be selected by the assigned Process Engineer and Physicist with the concurrence of the test author and will be selected from those available as a result of scheduled discharge.

Phase II lot-charged material will be treated as if it were normal production. Aside from 800 pieces which are to be charged concurrently with the 10 Phase I monitor charges, the lot charged material will not be charged until after four of the Phase I monitor charges (discharged at 1/2 goal) have been examined at the 105-C Metal Examination Facility (MEF).

B. Data

No special data recordings are planned. If data are desired, data sheets and instructions will be provided by the test author with the concurrence of the reactor manager.

C. Goal Exposure

Phase I

- 1) Four columns will be discharged at 400 MWD/T
- 2) Four columns will be discharged at 800 MWD/T
- 3) Two columns will be discharged at 1000 MWD/T

Phase II

Discharge of the lot-charged material will be determined by the goal exposure plan in use for normal production material of the same geometry and charged during the same period.

Exposure Changes

Goal exposure changes may be made by request from the test author with the concurrence of reactor processing manager.

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D. Discharge

All monitor columns charged under Phase I may be discharged prior to reaching goal discharge exposures after two failures have occurred providing all columns can be specially picked up.

If a failure occurs in the lot charged material, the material will be treated as if it were normal production fuel.

E. Operating Conditions and Limits

The operating limits and conditions which are in use for normal production OIIN fuel will apply toward this material.

4. General

A. Schedule

Fuel elements for Phase I have been fabricated, tested, and measured, and are ready for reactor charging. Approximately 800 pieces (identified as WZ002-A) are also ready and are to be lot charged at the same time. Reactor loading of the above material is requested for the first outage following approval of this test. A test schedule is appended.

B. Duration

Irradiation of the Phase I material will require about five months. Phase II will extend over a period of about fourteen months. This test authorization will terminate on December 1, 1963.

C. Post-Irradiation Examinations (105-C - MEF)

All pre-measured fuel elements will:

- 1) be weaseled and visually inspected for surface conditions,
- 2) be measured for length, warp, and diameter changes (OD₁, OD₂, OD₃, ID₅, and ID₇),
- 3) have weight recorded (odd pieces 1 through 23)
- 4) be bond tested for total count if equipment is available.

Selected pieces may be set aside for stripping and bare core measurements depending on either the preliminary visual examination results or a later analysis of the measured data. Also, selected elements may be sent to Radiometallurgy for destructive examinations.

D. Costs

The primary outage time losses resulting from this test will be associated with charge-discharge and special pickup of ten tubes of material. All incremental costs associated with the performance of this test may be charged to XXXX-5R24-XXX.73. Outage time requirements are listed below for scheduling purposes.

<u>Job</u>	<u>Processing Time</u>	<u>Elevator Time</u>
Charge	1/4 mh/tube	1/6 hr/tube
Special pickup	1/2 mh/tube	- - - - -

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E. Hazards

It is understood that this test program entails some potential risk to production should the extruded dingot cores not perform as well as current production. It is expected that this risk can be minimized by thorough pre-irradiation core evaluation and by the early discharge and examination of monitor columns prior to lot charging tonnage quantities. Also, limited irradiation experience is available for alpha extruded core material and it indicates only small differences would be expected. No unusual hazards are associated with this program and it is felt that the potential advantages outlined in the Basis and Justification for this test do justify a small risk to IPD's production.

RESPONSIBILITIES

Fuels Preparation Department

Responsibilities assigned to the Fuels Preparation Department are authorized by HW-72541-B, which authorizes fabrication of the test material and assigns responsibilities within Fuels Preparation Department necessary to carrying out this production test.

Irradiation Processing Department

Research and Engineering Section

Process and Reactor Development Sub-Section - shall be responsible for coordination of the test, analysis of operating data, reporting of in-reactor performance, and for provision of bases for operating limits.

Process Technology Sub-Section - shall be responsible for providing assistance to both the Processing Operation and the Process and Reactor Development Sub-Section in pre-shutdown scheduling, in charging the test materials, in selection of test channel locations, for forwarding operating data to the author, and for specification of operating limits.

Operational Physics Sub-Section - shall be responsible for providing assistance in selecting test channel locations, and for reactivity adjustments as required by this test.

Component Testing Unit - shall be responsible for post-irradiation fuel element examination and measurements.

Manufacturing Section

Production Scheduling - shall be responsible for scheduling discharge of the test material, for ordering the lot charged material under Phase II, and for maintaining accurate records for the material charged under this program.

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RESPONSIBILITIES (continued)

Manufacturing Section

B-C Reactor Operation

B Processing Operation - shall be responsible for scheduling, for operational safety and production continuity of the reactor, and for charging the test material.

B Maintenance Operations - shall be responsible for all maintenance work required to perform this test.

M. A. Clinton

M. A. Clinton
Reactor Fuels Unit
Process and Reactor Development
Research and Engineering Section
IRRADIATION PROCESSING DEPARTMENT

MAC:gb

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APPROVALS

J. H. Brown, Manager
Process & Reactor Development Subsection
IRRADIATION PROCESSING DEPARTMENT

J. W. Baker, Manager
B Processing Operation
IRRADIATION PROCESSING DEPARTMENT

R. W. Reid, Manager
Process Technology Subsection
IRRADIATION PROCESSING DEPARTMENT

W. J. Ferguson, Manager
B-C Reactor Operation
IRRADIATION PROCESSING DEPARTMENT

G. C. Fullmer, Manager
Operational Physics Subsection
IRRADIATION PROCESSING DEPARTMENT

C. A. Priode, Manager
Production Operation
IRRADIATION PROCESSING DEPARTMENT

C. G. Lewis, Manager
Testing Subsection
IRRADIATION PROCESSING DEPARTMENT

E. R. Astley, Manager
Applied Reactor Engineering
IRRADIATION PROCESSING DEPARTMENT

O. H. Greager, Manager
Research and Engineering Section
IRRADIATION PROCESSING DEPARTMENT

J. C. Schroeder, Manager
Manufacturing Section
IRRADIATION PROCESSING DEPARTMENT

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TABLE I

Acceptance Testing Schedule For Alpha Extruded DIngot
CY-1962

March 1	Charge 35 tubes including 10 Phase I monitor charges	
April		
May	Discharge 4 Phase I tubes at 400 MWD/T	
June	Charge 25 tons Phase II.	Discharge 25 tubes Phase II
July	Charge 25 tons Phase II	Discharge 4 tubes Phase I at 800 MWD/T
August	Charge 25 tons Phase II	Discharge 2 tubes Phase I at 1000 MWD/T
September	Charge 25 tons Phase II	
October	Charge 25 tons Phase II	Discharge 25 tons Phase II
November	Charge 25 tons Phase II	Discharge 25 tons Phase II
December	Charge 25 tons Phase II	Discharge 25 tons Phase II

(6 months at 90 tons prior to full acceptance. This will require participation of more than one old reactor and will be authorized by a supplement to this PT or a PITA).

Phase III The 32 tube statistically designed test comparing alpha extrusion methods versus rolling will probably not take place, at the earliest, before the last quarter of CY-1962.

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